



Transportation Synthesis Report

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Winter Operations Measures

Prepared for
Bureau of Highway Operations
Division of Transportation Infrastructure Development

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Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WisDOT technical staff in highway development, construction and operations. Online and print sources include NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs, and related academic and industry research.

REQUEST FOR REPORT

As part of its Compass program, BHO is interested in creating tools that would be helpful for managing winter operations and creating an action plan for testing a few measures this upcoming winter. The RD&T program was asked to perform an information search to identify potential resources. Our focus, for the most part, is on Web sites and broad research efforts.

SUMMARY

A search of major transportation and municipal Web sites in the U.S. and Canada revealed several working methodologies for measuring the efficiency and effectiveness of winter maintenance operations.

1. **Ontario Ministry of Municipal Affairs and Housing.** In Ontario, municipalities are using formulae that calculate the efficiency and effectiveness of their winter road services.
2. **Ontario Ministry of Transportation—Integrating Technology for Winter Road Maintenance.** Ontario's Ministry of Transportation is investigating the use of on-board data recording systems incorporating global positioning systems for monitoring winter maintenance activities and performance.
3. **Ontario—Decision Support System for Winter Maintenance: Feasibility Demonstration.** The Ontario Ministry of Transportation is also crafting a decision support system for winter road maintenance.
4. **U.K.—Performance Audit Method for Winter Maintenance.** In the U.K., a university researcher has developed a model for measuring the performance of highway agencies, private consultants and others who decide when roads should be salted.
5. **Salt Institute—Salt & Highway Deicing.** Closer to home, the Salt Institute in Alexandria, VA has been promoting the idea of measuring actual highway performance in winter maintenance operations through the use of advanced Intelligent Transportation System (ITS) technologies. The technologies are expected to automate these performance measures and provide them in real time to snow-fighting supervisors.
6. **FHWA—Performance + Accountability = Public Support.** The Federal Highway Administration has been developing winter operations performance measures for the new National Transportation System.
7. **Pennsylvania DOT.** PENNDOT district maintenance staff have developed and implemented procedures and tools to help them curtail the amount of anti-skid, anti-icing and de-icing material used while still exceeding customer expectations for safe and efficient winter travel.
8. **NAS—Fifth International Symposium on Snow Removal and Ice Control Technology.** The National Association of Sciences year 2000 Symposium on Snow Removal and Ice Control Technology brought together a number of experts in the area of winter performance measurement. The full text of several of the presentations can be found in Transportation Research Record No. 1741 *Advances and Issues in Snow-Removal and Ice-Control Technology*.

1. Ontario Ministry of Municipal Affairs and Housing

http://www.mah.gov.on.ca/scripts/index.asp?action=31&P_ID=5600&N_ID=1&PT_ID=1&U_ID=0

The Municipal Performance Measurement Program (MPMP) is a new initiative designed to provide Ontario taxpayers with useful information on service delivery, and municipalities with a tool to improve those services over time. The program requires municipalities to measure their performance in nine core municipal service areas, including Roads. The Ministry suggests that municipalities use the following formulae to measure their performance in winter road services:

- Operating Costs for Winter Control—operating costs for winter control maintenance of roadways, divided by total lane kilometers maintained in winter, equals total cost per lane kilometer. This is a measure of “efficiency,” to determine operating costs for winter control maintenance of roadways per lane kilometer. The objective is efficient winter control operation.
- Condition of Roads—number of paved lane kilometers rated as good to very good, divided by total number of paved lane kilometers tested, multiplied by 100. This is a measure of “effectiveness,” to determine the percentage of paved lane kilometers where condition is rated as good to very good. The objective is to provide a paved lane system that has a pavement condition that meets municipal standards.
- Winter Event Responses—the number of winter event responses that meet or exceed municipal road maintenance standards, divided by total number of winter events, multiplied by 100. This is a measure of “effectiveness,” to determine the percentage of winter event responses that meet or exceed municipal road maintenance standards. The objective is to provide appropriate winter response.

In its report to the Ministry, one of the municipalities—Middlesex—cited the following factors that can influence the results of the performance measurements: severity of the winter (amount of snowfall, incidents of icy conditions); levels of approved service; length of road system (in particular length of major arterial roads within the road system); and proximity to an urban center.

The Middlesex Corporate Services Committee also noted that: “In and of themselves, the figures that we derived from the formulas do not mean a lot. If we had historic data we could determine if the county’s performance has changed. However, until we are several years into the program, consistent historical data will not be available.”

2. Integrating Technology for Winter Road Maintenance

Ministry of Transportation Ontario (MTO), Research and Development Branch

<http://216.239.53.100/search?q=cache:RDsVbGET4SwC:www.mto.gov.on.ca/english/transtek/m2001/96-97fs.pdf>

Scroll down to page 3: Tools for Monitoring Maintenance Activities and Performance

Three categories of technology/practices are under investigation by MTO, including tools for monitoring maintenance activities and performance:

- On-board data recording systems incorporating global positioning systems (GPS) have the capability to identify where equipment is working at any time and the location where material is spread.
- Information from these systems can be used to ensure adherence to operational policies such as application rates and spreading speeds.
- For real-time scenarios and historical data collection, the information provided (equipment activity) is directly related to RWIS information (road conditions).
- Road surface condition monitoring equipment measures friction of driving surface during winter conditions.
- Information can be used to establish data on effects of material applications and rates of application.
- Under a partnership with Transport Canada, the device is also being tested on airport runways.

3. Decision Support System for Winter Maintenance: Feasibility Demonstration

Aurora Project

<http://216.239.53.100/search?q=cache:kxXMfEG-HcIC:www.aurora-program.org/pdf/decision1and2.pdf>

Scroll to page 10, Section 3.2: MTO Evaluation of Recommended Application Rates

Three measures of effectiveness have been defined by the MTO Aurora Project team for testing purposes:

- elapsed time between material application and bare pavement (defined as 10 percent snow cover);
- rate of clearing (rate of change of snow cover from time of material application until snow cover is 10 percent);
- binary measure where effective is defined as: snow cover is reduced between t_0 and t_x , where t_0 is time of material application and x is 30 minutes, one hour, or two hours.

Comparisons should account for differences between test cases due to: air or surface temperature, drifting, initial snow cover, traffic, sunlight and prior applications or retention of salt on the surface between applications. Variables have been introduced to account for each of these. Study variables are defined in Appendix C. Two types of analysis have been used thus far: sorting of data into similar conditions, and multi-variate linear regression. Sorting analysis is a more straightforward approach but requires a large database because sorting into similar conditions for several variables results in small samples for each relevant action. Sample results from sorting analyses are shown in Appendix C for dry salt, pre-wet salt and salt/sand mixes. (This analysis was to be completed after data collection during winter 2000-01.)

4. Performance Audit Method for Winter Maintenance

http://www.dot.state.mn.us/maint/files/sirwec_cd/thornes.pdf

By John E. Thornes, School of Geography and Environmental Sciences, University of Birmingham, United Kingdom. Contact at J.E.Thornes@bham.ac.uk

There is a need for a simple performance audit method that measures the consequences and value of correct and incorrect decisions to salt roads. A type 1 error is defined as when roads should have been salted but were not. A type 2 error is when roads were salted when they need not have been. Up to now these checks have been applied to the forecast providers only. This paper suggests that verification statistics can also be used to measure the performance of highway agencies and private consultants or whoever decides when roads should be salted.

5. Salt & Highway Deicing, Fall 2002, Salt Institute, Alexandria, VA

<http://www.saltinstitute.org/images/shd2-02.pdf> Scroll to last page article, “Ask Dr. Berger”

- **Q:** I understand the Salt Institute has been promoting the idea of measuring actual highway performance in winter maintenance operations rather than agency performance. How can this be done?
- **A:** Advanced ITS technologies are expected to automate these performance measures and provide them in real-time to snow-fighting supervisors. The idea is to measure outcomes like roadway friction rather than just outputs like the time and amount of salt applied. Field studies of roadway friction measurement have been done at the NASA Wallops flight facility, and in Iowa, Minnesota and Michigan. There has also been an ongoing, coordinated study in Norway.

6. Performance + Accountability = Public Support

By Richard Hanneman, President of Salt Institute: *Public Works* magazine, July 1996

<http://www.saltinstitute.org/pubstat/pubworks.html>

The Federal Highway Administration is forging ahead in developing performance measures for the new National Transportation System. Among the parameters of interest to snow fighters for which measures are being developed are speed (miles per hour, transit time, ton-miles per hour, dollar-miles per hour, and passenger-miles per hour); reliability (standard deviation of freight speed, percentage of "on-time" deliveries); "service quality;" response times for various emergencies; various measures of access such as convenience, comfort and personal security; crash fatalities and injuries and property loss; tons of airborne particulate matter; wasted motor fuels and various measures of financial cost. Public works managers will want to track carefully the progress of this path-breaking effort.

7. Pennsylvania DOT

Highlights from Strategic Environmental Management System

<http://www.gggc.state.pa.us/text/publictn/01GreenPlan/dot.htm> Scroll down to Winter Roads Maintenance

(Contact Ken Thornton at thornke@dot.state.pa.us.)

In 1997, Pennsylvania DOT began developing an environmental management system, to provide a comprehensive approach to integrating environmental considerations throughout the agency's complex operations. Over the last two winters, Engineering District 10 maintenance staff have developed and implemented procedures and tools to help them curtail the amount of anti-skid, anti-icing and de-icing material used while still exceeding customer expectations for safe and efficient winter travel. Preliminary survey results indicate that District 10 staff saved more than 3,000 tons of material agents using their improved procedures. By reducing their use of materials District 10 staff not only saved more than \$100,000 but also significantly reduced the impact on vegetation and ground water.

8. Fifth International Symposium on Snow Removal and Ice Control Technology

National Association of Sciences: Roanoke, Virginia, 2000

<http://216.239.39.100/search?q=cache:C-spE6uGzkYJ:gulliver.trb.org/publications/conf/snow-2000-pp.pdf+&hl=en&ie=UTF-8>

The presentations included:

- Performance-Based Assessment of Winter Maintenance Using Level of Service (LOS)
S. Edward Boselly III, Weather Solutions Group
Robert R. Blackburn, Blackburn & Associates
[See the complete paper, attached as a PDF file.] The authors present a performance-based assessment process for determining the Level of Service (LOS) provided by winter maintenance operations. The measure of effectiveness used in this assessment is a wintertime pavement condition index (PCI). The PCI is a set of eight road surface descriptions that can be used to determine the distribution of within-storm and end-of-storm LOS achieved through maintenance action. The index can be used to help identify appropriate material application rates to be used during different snow and ice control strategy/tactic combinations for various storm types, pavement conditions, cycle times or traffic flow levels. The performance-based assessment technique allows agencies to determine not only how well they are doing relative to the LOS goals: it provides a mechanism for determining the need for additional resources or improved technology.
- The Development of Customer-Based Level of Service Measures for Snow and Ice Control by Caltrans
Kris Kuhl, PE and Steve Takigawa, PE
California Department of Transportation (Caltrans)
While driver surveys yield excellent information from the public's point of view, they do not provide specific, activity-based feedback through which Caltrans can improve internal operations, including snow and ice control. To address this concern, a pilot process called Snow and Ice Level of Service (Snow LOS) was tested on snow routes and implemented for the 1999-2000 winter season. The process is designed to be observation-based rather than measurement-based: "keep it simple," "let the highways speak for themselves," so that evaluation results will lead to better planning, improved work procedures and information sharing. More than 500, one-mile highway segments were reviewed under snow conditions by trained Caltrans evaluators. Each evaluation required observation or measurement of 14 elements on a pass/fail basis. At the completion of the season, the results were tabulated and provided to the state highway transportation districts with significant snow and ice maintenance. Caltrans would use this information to improve snow and ice operations and customer service. The long-term goal for the program is to link winter maintenance expenditures to snowfall and level of service provided.
- Economic Evaluation of Snow-Removal Level by Applying the Contingent Valuation Method
Yasuhisa Hayashiyama, Tohoku University, Japan
Shintaro Tanabe, Hokkaido Development Engineering Center, Japan
Fumihito Hara, Hokkaido Development Engineering Center, Japan
(Published in Transportation Research Record 1741, 2001, *Advances and Issues in Snow-Removal and Ice-Control Technology*, pp 183-190.)
- Methods for Measuring and Reporting Winter Maintenance Activities
Torgeir Vaa, SINTEF Transport Engineering
(Transportation Research Record 1741, pp 152-158)
- Measuring the Efficiency of Winter Maintenance Practices
Rand Decker, John L. Bignel, Cambria M. Lambertsen and Kristie Porter: University of Utah
(Transportation Research Record 1741, pp 167-175)